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Identifying Pedophiles by Visualizing Vein Patterns from Color Skin Images

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***Abstract*— Since vein patterns are nearly invisible in color images it is difficult to evidence images for forensic identification images. In this paper, we propose an algorithm based on image mapping to visualize vein patterns. It extracts information from a pair of synchronized color and near infrared (NIR) images, and uses a neural network (NN) to map RGB values to NIR intensities. The proposed algorithm was examined on a database with 300 pairs of color and NIR images collected from the forearms of 150 subjects. The automatic matching results from the proposed algorithm were better than those from our previous method, and comparable to the results from matching NIR images with NIR images. And using the recovery technique, recognize the pedophile who is doing the crime.**

***Keywords*— Put your keywords here, keywords are separated by comma.**

I. INTRODUCTION

Personal identification is a critical process in forensic investigation. Significant research effort has been expended to develop face, fingerprint, palm vein, DNA, and dental identification systems. These systems are regularly used by law enforcement agents around the world. However, they are not applicable in cases where only partial non-facial skin of criminals or victims is observable in photographic evidence or digital images. Sex offenses against children are among these cases. Pedophiles are usually careful not to show their faces in images for fear of identification.

The problem of child pornography is increasing because of the proliferation of such material electronically and the lack of effective identification technology. The U.S. Customs Service estimated that 100,000 websites offer child pornography. Development of effective methods to identify pedophiles based on images of partial skin is an essential measure to stop child sexual exploitation. Tattoos and skin marks are possible features that can be used in these cases. However, tattoos are neither unique nor ubiquitous, and the skin exposed in evidence images may not have a sufficient number of identifiable skin marks for personal identification. Traditionally, it was impossible to use vein patterns for forensic identification, because they were almost invisible to the naked eye in color images taken by consumer cameras.

II. RELATED WORKS

In paper [2], an algorithm was proposed to uncover vein patterns from the skin exposed in color images for personal identification. Based on the principles of optics and skin characterisctics, they modelled the inverse process of skin color formation in an image and derived spatial distributions of biophysical parameters from color images.

H. Zhang et al. [3] proposed a color optimization scheme to derive the image of biophysical parameters to obtain training parameters and an automatic matching algorithms for vein identification. An algorithm for JPEG blocking artifacts in skin images that adversely affect forensic recognition was proposed in [4]. A palm vein pattern authentication technology that uses vescular patterns as personal identification data was introduced in [5].

Paper [6] proposes a novel technique to analyse the infrared vein patterns in the back of the hand for biometric purposes. The technique utilizes the minutiae features extracted from the vein patterns for recognition, which include bifurcation points and ending points.

The above studies show that not much works have been done using vein patterns hidden in the color image to recognize the person's real identity. Traditionally, it was difficult to use vein patterns in evidence images for forensic identification, because they were nearly invisible in color images. In this paper, we propose an algorithm to visualize vein patterns. The algorithm extracts information from a pair of synchronized color and NIR images, and uses a neural network to map RGB values to NIR intensities.

III. PROBLEM FORMULATION

It was difficult to use vein patterns in evidence images for forensic identification, because they were nearly invisible in color images. Until now, no one studies vein patterns hidden in the color images how to recognize the person's real identity. Personal identification is a critical process in forensic investigation. Significant research effort has been expended to develop face, fingerprint, palm print, DNA, and dental identification systems. These systems are regularly used by law enforcement agents around the world.

However, they are not applicable in cases where only partial non-facial skin of criminals or victims is observable in photographic evidence or digital images. Sex offenses against children are among these cases. Pedophiles are usually careful not to show their faces in images for fear of identification. The problem of child pornography is increasing because of the proliferation of such material electronically and the lack of effective identification technology. The U.S. Customs Service estimated that 100,000 websites offer child pornography. Development of effective methods to identify pedophiles based on images of partial skin is an essential measure to stop child sexual exploitation. So the primary aim of this paper is to develop algorithms and study how visualizing vein patterns hidden in color images and recognize the person who is presented in the video using the edge recovery techniques so that criminal and victim identification can be performed based on vein patterns.

IV. PROPOSED METHOD

The proposed method uses 3 approaches for uncovering vein patterns from color skin images.

A. RGB-NIR MAPPING

Based on RGB-NIR mapping. It extracts information from a pair of synchronized color and NIR images and uses a neural network to map RGB values to NIR.

B. AUTOMATIC MATCHING ALGORITHM

Using an automatic matching algorithm, we match resultant images from the RGB-NIR mapping approach and find that its matching result is comparable to the result from matching NIR images.

C. VEIN VISUALISING ALGORITHM

In this section, we present our vein visualizing algorithm. It is composed of two parts: a mapping model and an automatic neural network weight adjustment scheme.

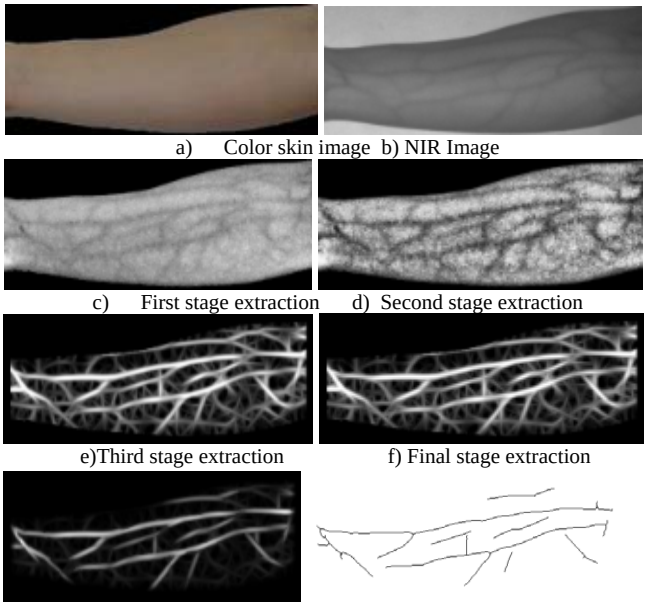
1) Automatic Matching Algorithm: Using an automatic matching algorithm, we match resultant images from the RGB-NIR mapping approach and find that its matching result is comparable to the result from matching NIR images. The camera simultaneously measures visible and NIR light spectrums through a single lens using two channels. The first channel has a Bayer mosaic color imager that only captures visible light, while the second channel has a monochrome imager for NIR light. The color and NIR images are perfectly registered and synchronized. We collected data from the forearms of ten Asian males, and selected the pair with the best image quality shown in Fig. 1 for model construction.

Fig. 1 a) RGB image b) NIR image

We used the RGB values as inputs and the corresponding NIR intensity as target outputs to train a three-layered feed-forward neural network. The transfer functions in the hidden and output layers

2) *An Automatic Neural Network Weight Adjustment Scheme*: The illumination condition can significantly influence the skin color in images. Therefore, the performance of the RGB-based mapping model deteriorates if the imaging condition in testing images is very different from that of the training image. To compensate it, we used an automatic intensity adjustment scheme [4]. In addition, veins look green in a color image because the ratio of G value to the sum of RGB values in vein pixels is higher than that in generic skin pixels. Therefore, the mapping approach is more sensitive to the G value. In this section, we propose a new scheme which automatically adjusts the NN input-layer weights to further improve the robustness of the algorithm.

Firstly, the contrasts of visualized images are normalized by the contrast-limited adaptive histogram equalization (CLAHE) method. The vein patterns are uniformly sampled and represented by a set of points for matching. Obviously, high quality images with longer veins and more efficient points will achieve more accurate matching results. Fig. 2 shows the procedure of vein extraction.



a) Color skin image b) NIR Image

c) First stage extraction d) Second stage extraction

e)Third stage extraction f) Final stage extraction

Fig. 2 Vein Pattern extraction

Fig. 3 shows the effectiveness of the adjustment scheme. After adjusting the NN weights, the enhanced vein image and its skeletonized result contain longer and clearer vein patterns.

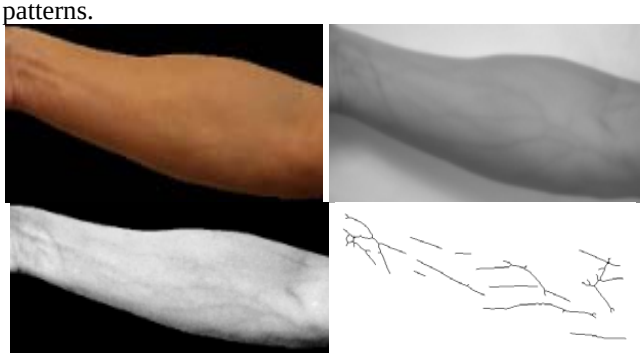


Fig. 3 NN weight adjustment results

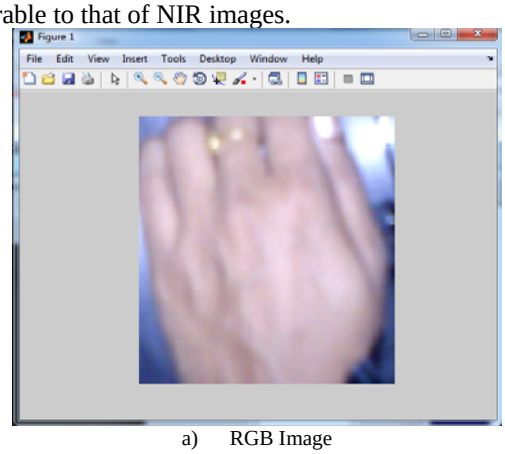
3) *Recovery techniques:* Edge recovery technique can be used to recognize the pedophile who has committed the crime. Vein recognition technology is secure because the authentication data exists inside the body and is therefore very difficult to forge. It is highly accurate. This technology can be used in various fields like banking, hospitals, government offices, in passport issuing etc**.**

V. EXPERIMENTAL RESULTS

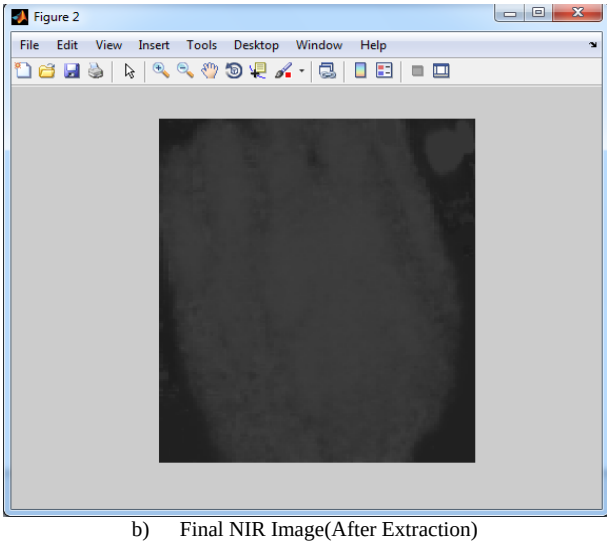
We used our vein extraction and matching algorithms to verify the visualized vein patterns. In the case where only a partial image of a forearm is available in the database, we performed manual matching. Our database contains 5 color images and 5 NIR images. The images were collected on two separate occasions, at an interval of around two weeks. In our database, each subject in each session has one color image and one NIR image.

The color images were collected by Nikon D70s and Canon 500D cameras, while the NIR were collected by a JAI camera. Note that the color and NIR images were not captured simultaneously by the 2-CCD multi-spectral camera. In addition, the camera models and imaging conditions were different from those of the training image. Cumulative match curves generated from the matching results were used as a performance indicator.

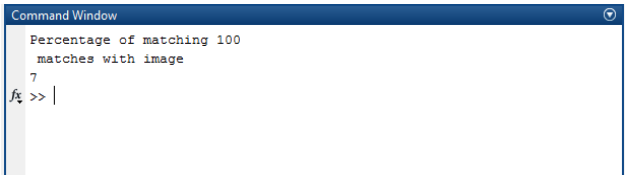
Figure 4 shows the sample outputs that we have obtained. The matching experiments on a database with 5 forearms shows that the identification accuracy of the proposed study was higher than our previous optical method, and comparable to that of NIR images.



a) RGB Image



b) Final NIR Image(After Extraction)



c) Percentage match

Fig 4: Output

VI. CONCLUSION

This paper mainly focused on the study of how the vein patterns can be visualized from the color skin images and recognize the person who is doing the crime, using some recovery techniques. For this purpose we have used an algorithm which extracts information from synchronized color and NIR images. An automatic NN weight adjustment scheme was also proposed to improve the performance. The matching experiments on a database with images from 5 forearms that the identification accuracy of the proposed study was higher than our previous optical method, and comparable to that of NIR images.

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